CHAPTER 6
VENTILATION

Section I. DEFINITION AND AVAILABLE EQUIPMENT

6-1. Definition

Ventilation is the process of supplying outside air to or removing inside air from any space. It is done for purposes of removing odors, noxious gases, or heat, and may be accomplished by natural or mechanical means or both.

6-2. Exhaust Fans

a. Description. Fans are divided into two general classifications: axial flow fans in which the air flows parallel to the fan axle, and centrifugal flow fans in which the impeller rotates within a scroll type housing and the air is discharged in a direction perpendicular to the fan axle. In general, centrifugal fans are used where it is necessary to move air against appreciable pressure, such as may be created by a duct system. Vane-axial and tube-axial fans mounted in closely fitted cylinders may be similarly used where a high noise level is permitted. Propeller fans, which constitute the largest class of axial flow fans, are customarily used for free delivery of relatively large quantities of air against little resistance. They are usually simple in construction and mounted within a plate or ring. They may be directly connected to the shaft of the motor which drives them (fig. 6-1), or they may be belt driven (fig. 6-2). Because of their operating characteristics and relatively low cost, propeller fans find their greatest use in ventilating work. Fan manufacturers publish data which make it possible to select the fan best suited to meet requirements. In addition, capacity tables usually indicate the most efficient operating speed, which is also usually the speed at which operation is quietest. This should be given particular consideration if fans are large, if they operate for long periods, or if quietness of operation is important. Propeller type exhaust fans come in a variety of sizes ranging from 300 to 75,000 c.f.m. capacity. They are sometimes incorporated in factory-built penthouses or roof caps. They may be provided with automatic check louvers to prevent air flow when the fan is not in operation. Where air is exhausted through a duct system, such as might be conncted to a hood, centrifugal fans are usually used. If a fan must handle hot or corrosive fumes, it should be so designed that both the bearing of the fan and the motor are not in the air stream. Although ventilating fans are usually single-speed, they may be equipped with two-speed or multispeed motors to make it easy to adjust fan speed to a variety of operating conditions.

b. Sizing. The following minimum information is needed to select the proper type and size of fan:

(1) Capacity in cubic feet per minute (c.f.m.)

(2) System resistance in terms of static pressure, if any

(3) Type of application, including nature of contaminated air handled

(4) Arrangement of system and space available

(5) Sound-level requirements of space served

(6) Horsepower and rpm of motive power available.

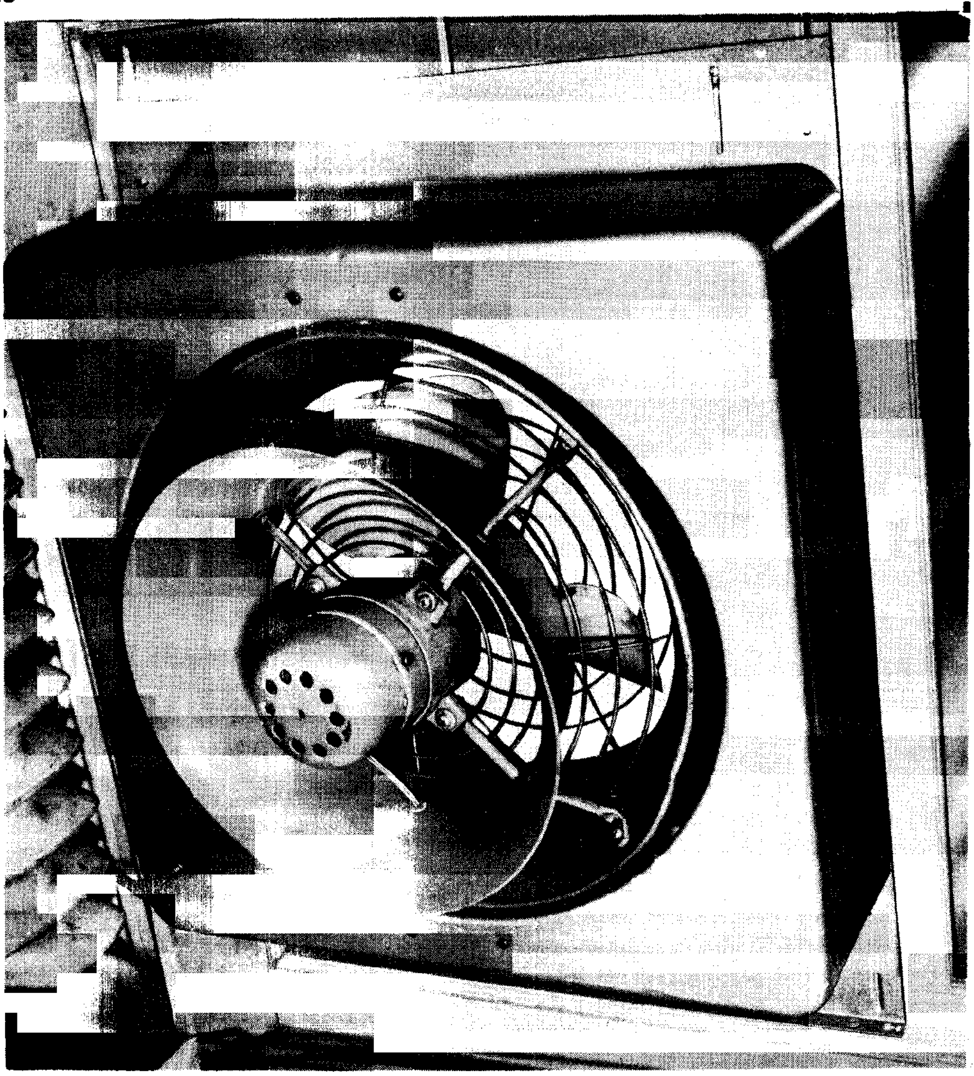


Figure 6-1. Direct-connected propeller fan.

6-3. Unit Ventilators

Unit ventilators are primarily designed to ventilate and cool by the introduction of outside air and the improvement of air circulation within the space. They may also include heating coils for providing warm air and air filters for cleaning the air. Automatic controls may be used for regulating air temperature (fig. 6-3). These units discharge air vertically upward and are best located along outside walls, preferably beneath windows. Heating coils, when used, may be supplied with either steam or forced hot water from a central boiler. Heating coils may be of only sufficient capacity to heat the air handled to a comfortable discharge temperature or may be large enough to supply enough heat to overcome the entire heat loss of the space served. Temperature control may be effected by air dampers which proportion the relative quantities of outdoor and recirculated air, or by adjustment of the rate of hot water or steam flow to the heating coil. Satisfactory ventilation also requires exhaust openings adequately sized and properly located to facilitate the flow of air through the space to be ventilated (para 6-7).

6-4. Air Ducts

Air ducts for use with ventilation systems are similar to those required for warm air systems (para 5-5). The design and fabrication of metal ducts are covered in chapters 10 and 11.

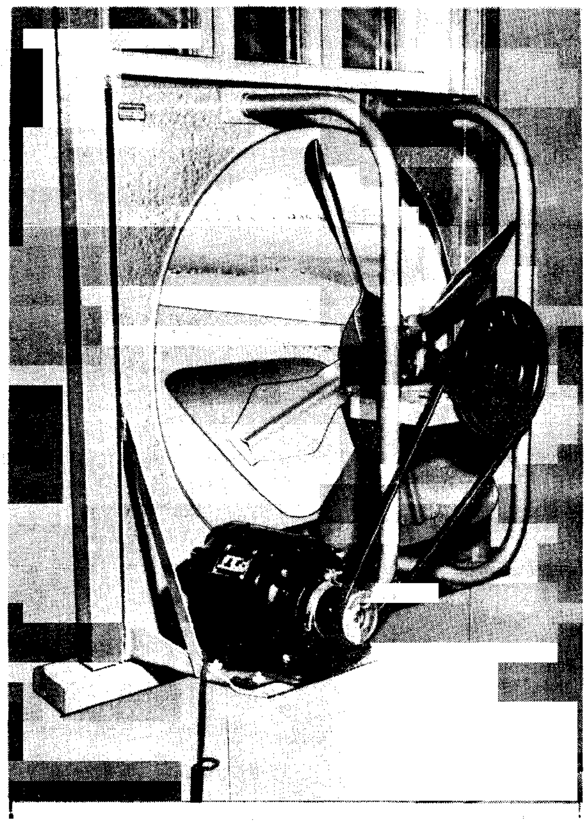


Figure 6-2. Belt-driven propeller fan.

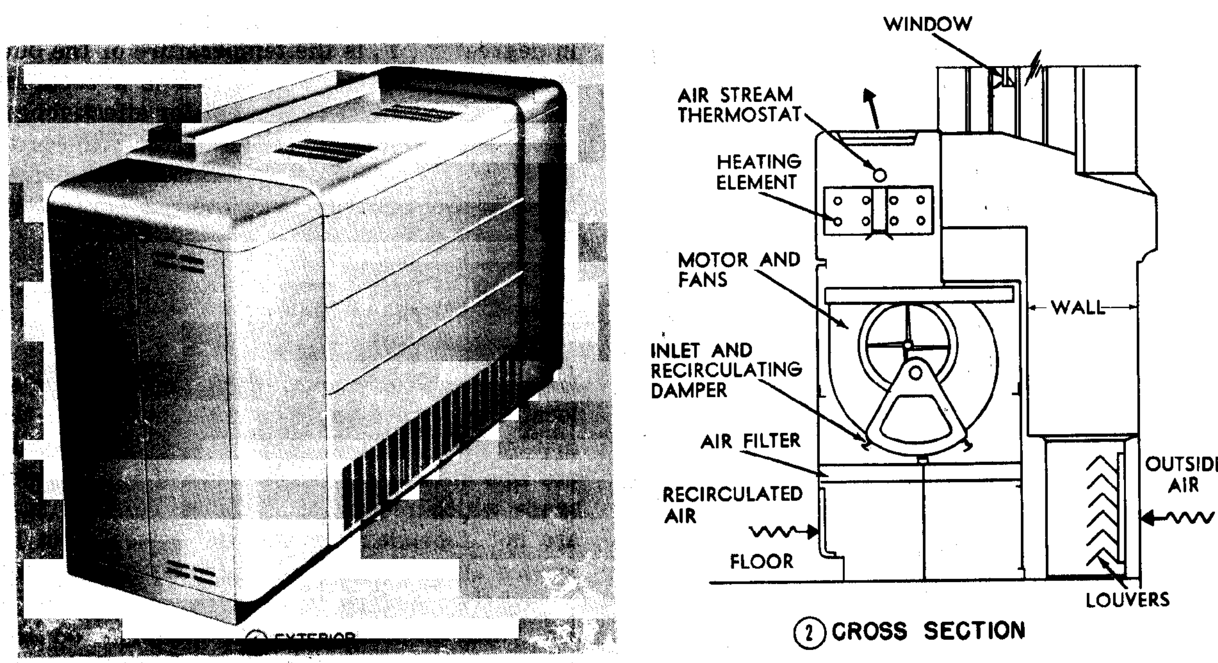


Figure 6-3. Unit ventilator.

Section II. DESIGN OF SYSTEMS

6-5. Ventilation Requirements

In addition to reducing odors, ventilation may be used to reduce building temperatures by drawing large volumes of outside air through the building whenever outside air temperatures are lower. For example, the cooling effect of the relatively cool evening or night air can be utilized. Desirable air quantities range from a 1-minute air change in extremely hot climates to a 2- or 3-minute change in milder climates. Where ventilation is to be used to remove heat given off by furnaces, machinery, or other equipment, the required air volume can be determined by selecting the desired indoor temperature and applying the formula:

$$(Q = \frac{H}{.018}(T_1 - T_0)$$

where Q is the air flow in cubic feet per minute, H is the heat to be removed in B.t.u. per minute, T_1 is the desired inside temperature in degrees F, and T_0 is the prevailing outside temperature in degrees F.

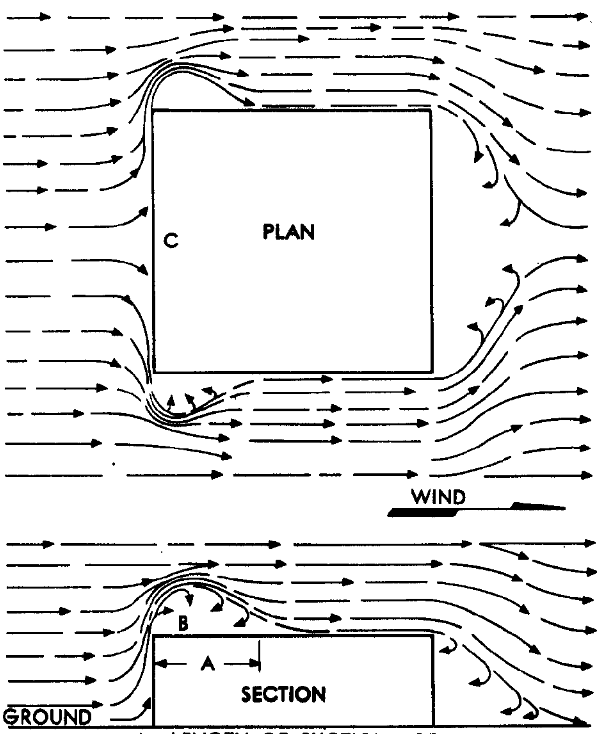


Figure 6-4. Effect of wind forces on building ventilation.

6-6. Use of Natural Ventilation

The natural forces available for ventilating buildings are wind forces and the difference in temperature between the air inside and outside the building, which produces a stack effect within the building. These forces and the ventilation produced by them are necessarily variable. In considering the effect of wind forces, account must be taken of the average wind velocity, wind direction, seasonable and daily variations, and local interference from nearby buildings or other obstructions. The general effect of wind forces on the surfaces of a building is shown in figure 6-4. The quantity of air forced through ventilation openings by wind can be calculated from the formula:

$$Q = E \times A \times V$$

where Q is the air flow in cubic feet per minute, A is the free area of inlet or outlet (assumed equal) in square feet, H is the height from inlet to outlet in feet, T_1 is the average temperature of the indoor air in the height H in degrees F., T_2 is the temperature of the outdoor air in degrees F, and 9.4 is a constant including a value of 65 percent for effectiveness of opening. This constant should be reduced to 7.2 if conditions are not favorable for the passage of air between floors of a multistory building.

6-7. Location of Equipment and Air Openings

Air supply and exhaust openings should be so located that they work together to provide the maximum amount of ventilation and to distribute this outside air to all parts of the interior space which require it. Exhaust fans, as they are not dependent on natural sources, can be located almost anywhere and should be located where they will remove the most undesirable air. Natural draft exhaust openings, on the other hand, must be located where they will

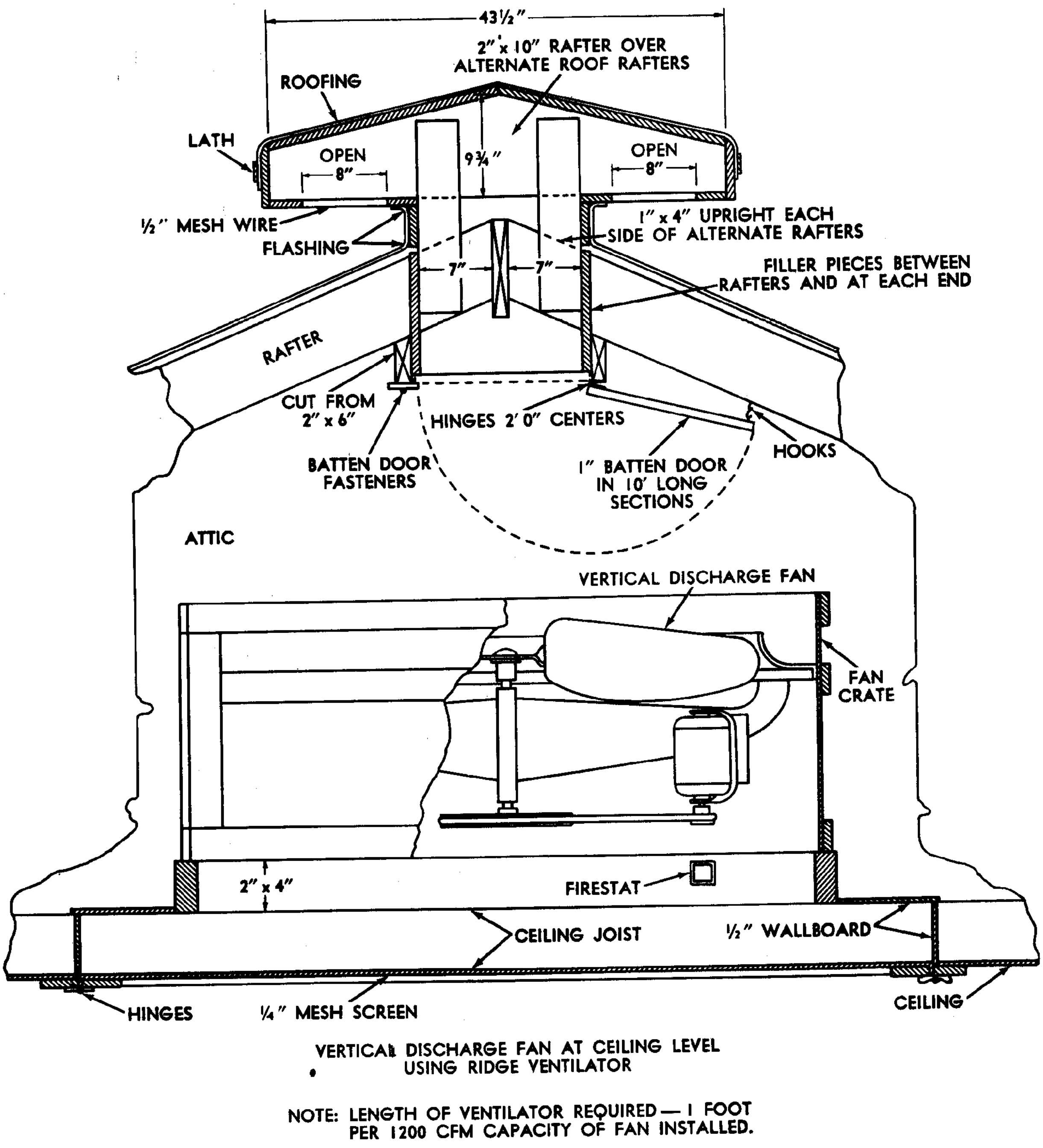


Figure 6–5. Vertical fan and roof monitor.

take the greatest advantage of suction areas caused by wind current. As can be seen from figure 6–4, the best locations of outlets are: on the side of the building directly opposite the direction of the prevailing wind; on the roof in the low-pressure area near the windward side, caused by the rise of the wind as it strikes the windward wall; on the side adjacent to the windward face where low-pressure areas occur; and, in roof ventilators or stacks. To

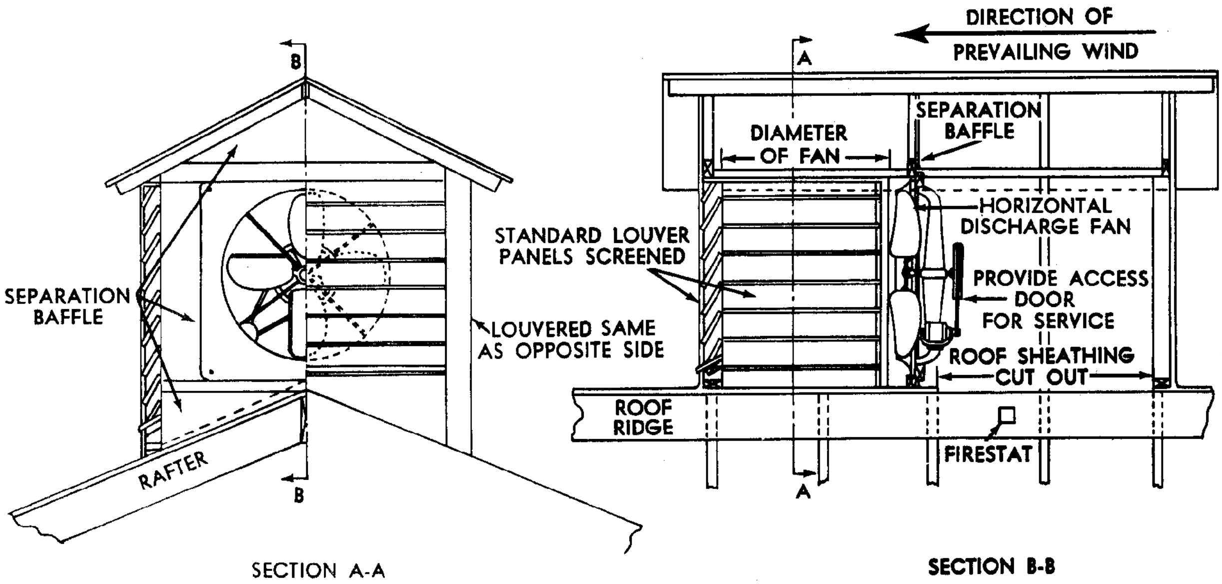


Figure 6–6. Horizontal discharge fan in roof monitor.

further take advantage of air-circulation forces caused by temperature difference, inlet openings should be located near the bottom and outlet openings near the top of buildings. The vertical distance between these openings should be as great as practicable. Inlet openings depending on wind pressure should not be obstructed by buildings, trees, or other objects. Greatest flow per square foot of total opening with natural draft systems is obtained by using inlet and outlet openings of approximately equal areas. Avoid direct short circuits between openings on two sides of a high level. Where wind velocity is depended on and wind direction is variable, openings should be provided on all sides of the building and possibly through roof monitors so that full advantage may be taken of wind currents, regardless of direction. Where it is desired to remove heat from furnaces or other sources by natural ventilation, it is best to locate these heat sources at the end of the building exposed to prevailing winds so that the suction created by the jump of the wind near the windward end can be utilized to exhaust air at that point. Details of construction of roof monitors and the protection of air openings are shown in figures 6–5 to 6–8.

6–8. Exhaust Hoods

a. Purpose. Undesirable gases or fumes from local sources such as spray booths or cooking equipment can best be removed by capturing these contaminants at the source and removing them through an exhaust system. Where such systems can be used they give more positive ventilation control, a reduction in air handled, and much better air conditions than can be obtained through general ventilation methods. This is so because a room ventilating fan remote from the source of air contamination requires that the contaminants spread throughout the room before they are removed. Such systems utilize enclosures or hoods to help capture the contaminants at the point of air exhaust.

b. Design. For maximum effectiveness a hood should enclose the source of contamination as completely as possible without interfering with the access to, or use of equipment. The effectiveness of the hood depends on the establishment of an adequate air velocity between the hood and the source of contamination so that contaminants will be drawn into the hood. The air velocity which must be maintained to move the contaminant is known as the "capture ve-

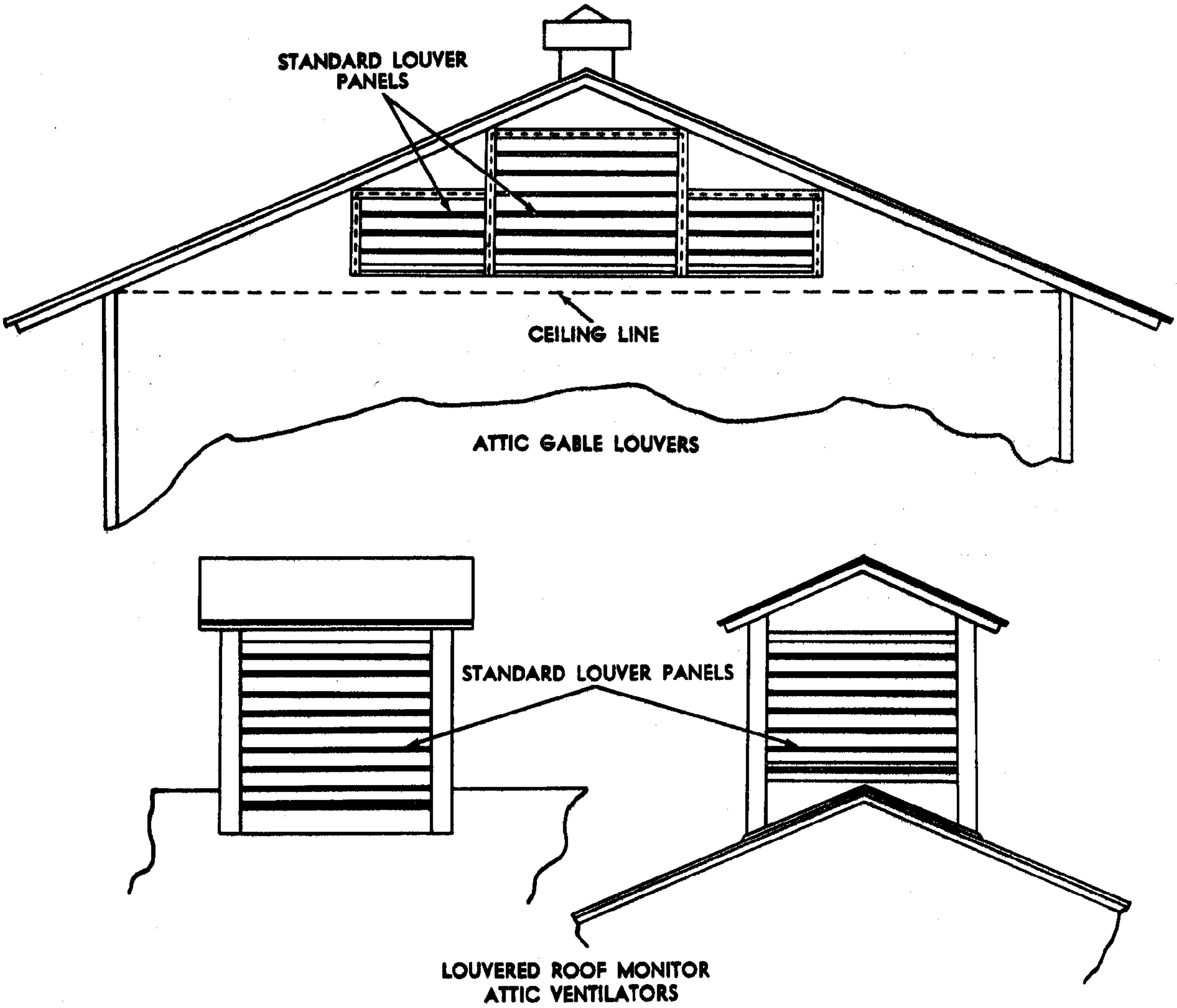
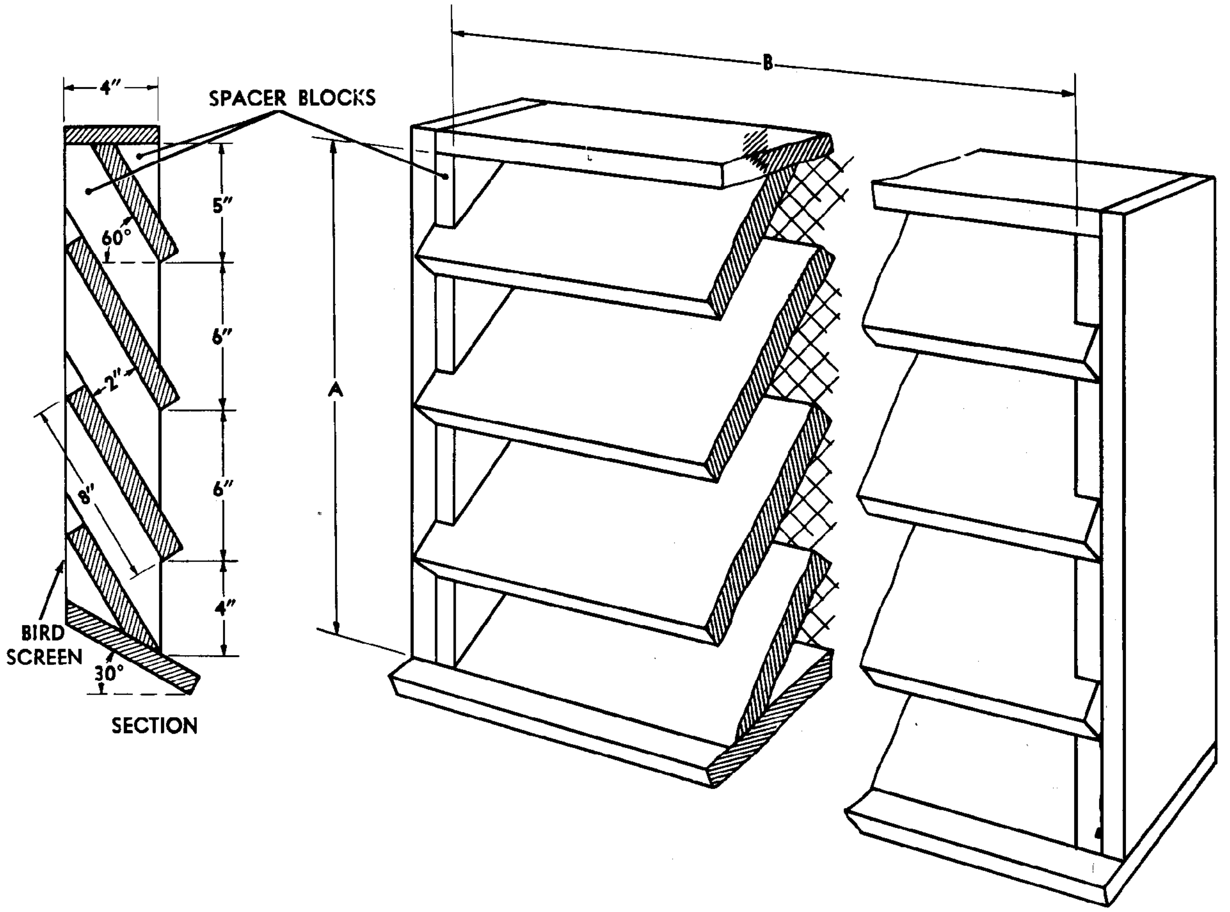


Figure 6-7. Louver installation.

locity." For contaminants released without noticeable movement, such as vapors for cooking operations, a minimum capture velocity of 50 f.p.m. should be maintained. Heavier materials released at greater velocities will require much greater capture velocity. The volume of air exhaust required is the product of the free area between the edge of the hood and the edge of the contaminant source and the capture velocity.

c. Range Hoods. A typical kitchen range hood is shown in figure 6-9. These hoods should extend outward at least 12 inches past the front and 6 inches past the sides of the range and have a height of 1½ feet or more so that they can handle momentary puffs of steam. To prevent interference with personnel, the hood should be kept above head level. The resulting opening between the hood and the range top requires a minimum velocity of at least 100 feet per minute across the open face of the hood for satisfactory performance. For large hoods the capture velocity at the edge of the hood can be maintained at a reduced air volume by the use of a double canopy (fig. 6-10). With this type of hood most of the air is drawn through a relatively narrow opening



CAPACITY OF LOUVER FRAME PANEL PER LINEAR FT BASED ON MAXIMUM 1200 FPM VELOCITY THROUGH FREE AREA								
NO OF LOUVERS	NO OF OPENINGS HIGH	DIMENSION A IN INCHES	SQ FT OF FREE AREA PER FOOT	CAPACITY OF INCREMENTS OF 1 FT FOR DIMENSION B				
				1 FT	2 FT	3 FT	4 FT	5 FT
2	1	9	.1667	200	400	600	800	1000
3	2	15	.333	400	800	1200	1600	2000
4	3	21	.500	600	1200	1800	2400	3000
5	4	27	.667	800	1600	2400	3200	4000
6	5	33	.833	1000	2000	3000	4000	5000
7	6	39	1.000	1200	2400	3600	4800	6000
8	7	45	1.167	1400	2800	4200	5600	7000
9	8	51	1.333	1600	3200	4800	6400	8000
10	9	57	1.500	1800	3600	5400	7200	9000
11	10	63	1.667	2000	4000	6000	8000	10000

NOTE: DO NOT EXCEED ABOVE CAPACITIES OR 1200 FPM VELOCITY
LOWER VELOCITIES ARE RECOMMENDED WHEN SPACE IS AVAILABLE

Figure 6-8. Wood louver details.

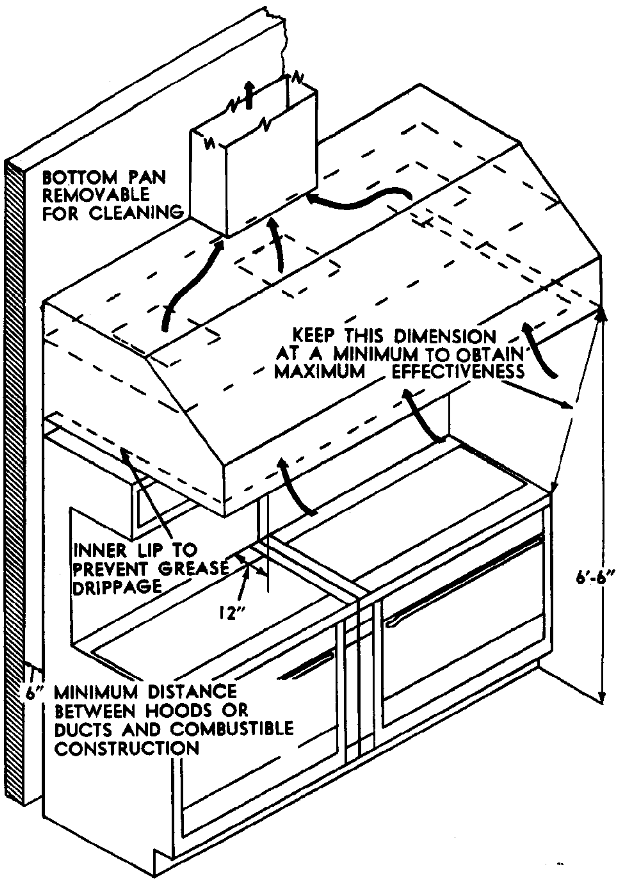


Figure 6–9. Simple range hood.

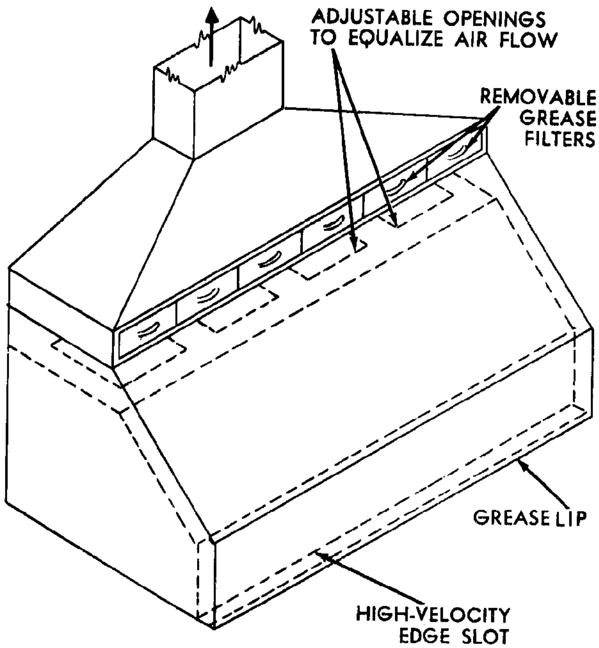


Figure 6–10. Double canopy hood.

Section III. INSTALLATION

6–9. Placement of Equipment

All fans, motors, and filters used in the ventilating system should be easily accessible for service and adjustment. The useful life of motors and fans depends on regular lubrication and inspection. Performance of any system where air filters are used is absolutely dependent on the cleaning and replacement of these filters before they reach an overloaded condition. If this equipment is placed where the filter is difficult to reach, the chances of its receiving proper maintenance are greatly reduced.

6–10. Sheet Metal Work

a. The design and fabrication of sheet metal ducts and fittings used in ventilating work is discussed in detail in chapters 10 and 11.

b. When the supply and return duct systems are connected directly to the fan inlet and outlet, these connections should be made by means of unpainted canvas or other flexible material to reduce excessive noise vibration.